# ACADEMIC PERSPECTIVES ON SUSTAINABILITY

**Researchers, professors, students and others working in academia are at the forefront of shaping the future of our world and in many cases, they are using simulation, design and engineering to do so. In this section of *REVEAL* Magazine, we hear directly from academics about their perspective on important trends and topics and learn about some of the work they are doing to create the future. This edition of *REVEAL* focuses on sustainability and we ask academics to tell us about how sustainability plays a role in the work that they do across various industries including additive manufacturing, life sciences, transportation and mobility, and renewable energy.**


**SIRIVATCH SHIMPALEE, PHD**
*Research Professor,*
*Chemical Engineering Department,*
*University of South Carolina*


**How has the simulation of fluid mechanics advanced your research in the area of renewable energy including fuel cells, energy storage, high temperature thermal system, and bioenergy?**

To understand heat, mass transport, and other physics such as electrochemical and electrokinetics inside renewable energy and bioenergy devices, the multiphysics simulation of fluid mechanics is necessary for research and development in these areas because those physics cannot be easily obtained by just performing experiments. For example, the water management inside a polymer electrolyte membrane (PEM) fuel cell (FC) is very important for maximizing its performance, since the byproduct of electrochemical reaction is not only electrical power but also water and heat. Condensed water inside a PEMFC can decrease its performance significantly, especially when it is clogged inside very thin (10 to 150 micrometer) porous layer, thus blocking the oxygen flowing to the catalyst surface and reducing oxygen transport to the oxygen reduction reaction (ORR). Computational simulation of this phenomena can definitely help researchers and developers to improve the design of porous materials and optimize operating condition of PEMFCs in order to maximize the ORR. Figure 1 shows an example of a XFlow simulation of water condensation and its evolution in side porous layers [1]. It can be seen that by changing operating conditions, liquid water presented inside this layer will be different. The results from the simulations can help improve the novel porous layer design, by the modification of catalyst and gas diffusion layer structures, and/or the dispersion of a platinum a deleted catalyst. Furthermore, this work should reduce cost and development time for improving PEMFC design. All research projects I have done and been doing will give great impact to several kinds of industry such as electric power, automotive, solar energy, gas, pharmaceutical, and porous-material industries. All of them require the deepest knowledge of transport phenomena to enhance their products and services for a sustainable future.


Figure 1.


[1] S. Shimpalee et al., Journal of The Electrochemical Society, 166 (8) F534-F543 (2019)


**For More Information**
www.che.sc.edu/researchfaculty/shimpalee.htm

## LUKA POCIVAVSEK, MD, PHD

*Vascular Surgery Fellow at University of Chicago*

**Medical simulation has a huge impact on the advancement of medical treatments. You co-founded Aruga, a medical device company specializing in vascular implants. However, your approach is different from traditional practices. You created a nature-inspired design of synthetic vascular reconstruction devices and successfully doubled the implant lifetime. Can you talk more about the importance of studying the intersection of nature and simulation, and the ability it gives to visualize the effectiveness of a treatment without resorting to experimental surgeries?**

Simulation is critical to integrating novel nature-inspired concepts into medical devices. Our approach capitalizes on the dynamic nature of arterial surfaces and integrates this into a unique vascular graft. These systems quickly become highly complex and involve interaction between a compliant graft, a dynamic pressure field, fluid flow, and surface fouling. To solve such a problem involves capturing correctly the geometrically non-linear elastic deformation of the graft surface, coupling the forces from the fluid to the solid deformation, and correctly modeling the interaction of platelets adhering to and de-adhering from the graft surface. Using Abaqus/Explicit, FSI, and advanced cohesive modeling, this complex simulation can be undertaken. On the basic-science side, it provides us with a tool to test the hypothesis of topography-driven de-adhesion, thus validating the physics behind our approach. On the applied clinical side, having an integrated simulation in place, allows us to do vast parameter sweeps of the different variables in our problem. Medical devices are often designed and tested under ideal conditions. However, these devices, when implanted, exist in a variety of complex loading conditions and under variable levels of fouling. Simulations allow us to test the behavior of our device under the various ranges of conditions may be encountered by the device during its lifetime. For instance, in the case of topographic grafts, the arterial-pulse pressure drives surface actuation. However, normal pulse pressure varies with distance from the heart, the mean arterial pressure, and even heart rate. Integrating these parameters into an experimental pre-implantation study would be nearly impossible. Simulation provides the answer and even allows the personalization of a given device to a particular operation.

L. Pocivavsek, J. Pugar, S. Velankar, E. Tzeng, W. Wagner, and E. Cerda, Geometric Tools for Controlling Soft Surface Adhesion, Nature Physics, 14, 948-953 (2018).

### For More Information and to Read the Full Article

https://www.nature.com/articles/s41567-018-0193-x
https://surgery.uchicago.edu

## TIMOTHY W. SIMPSON, PHD

*Paul Morrow Professor of Engineering Design and Manufacturing at the Pennsylvania State University*

**As an expert in the field, what do you think additive manufacturing's role can be in creating a more sustainable world? Do you think it will replace other forms of manufacturing completely or simply supplement existing processes?**

While the design freedom enabled by additive manufacturing (AM) is exciting, we often forget about the material freedom associated with "printing" parts layer-by-layer. With AM, we only add material where necessary, reducing the scrap and waste associated with many traditional manufacturing processes. In the aerospace industry, this is called the buy-to-fly ratio (amount of material purchased versus material in the part), and AM can help reduce this from upwards of 10:1 to 2:1 or 1.5:1 or better. While we are not at 1:1 yet, we are getting closer as we get better at designing for AM.

By combining AM's design and material freedoms, we can create lightweight structures that maximize material utilization using lattices, topology optimization, biomimicry, and other generative-design tools. Such structures use material more efficiently and require less build time, which saves energy. Improving material utilization may also make a more expensive material viable with AM. Better materials usually last longer, which means components do not need to be thrown away or replaced as frequently, both of which are better for the environment.

AM can also enable "manufacturing on demand:" make only the parts you need, when you need them, where you need them. This means less waste, less inventory, less transportation, etc. provided we can work through the regulatory, legal, and cybersecurity issues that often plague AM.

Finally, just because we can "print" something doesn't mean we should. Traditional processes have their strengths, and AM isn't going to replace traditional manufacturing. In fact, AM often needs other forms of manufacturing to make end-use parts; so, the real question is: how do we combine both to promote global sustainability efforts even more?

### For More Information

http://www.cimp-3d.org